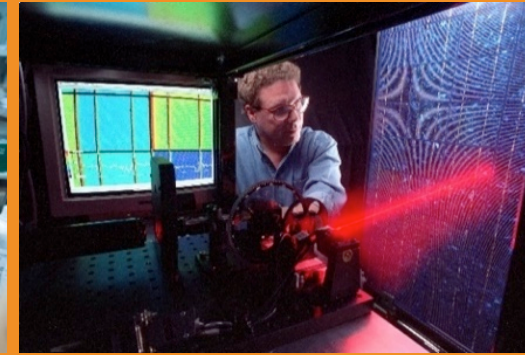
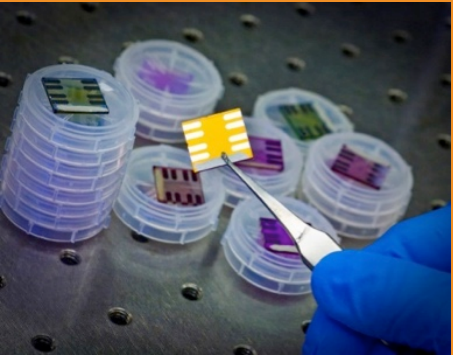


U.S. DEPARTMENT OF  
**ENERGY**

Office of ENERGY EFFICIENCY  
& RENEWABLE ENERGY

SOLAR ENERGY TECHNOLOGIES OFFICE



# Solar Energy Technologies Office Quarterly Stakeholder Webinar

Dr. Becca Jones-Albertus, Director  
Solar Energy Technologies Office  
September 10, 2020

[energy.gov/solar-office](https://energy.gov/solar-office)

# Solar Energy Technologies Office (SETO)

## WHAT WE DO

We fund early-stage research and development in three technology areas: **photovoltaics** (PV), **concentrating solar-thermal power** (CSP), and **systems integration**. We also **provide relevant and objective technical information** on solar energy to stakeholders and decision-makers.

## OUR PRIORITIES

Drive innovation in technology and soft cost reduction to make solar **affordable** and **accessible** for all Americans

Enable solar to support the **reliability, resilience**, and **security** of the grid

Create a sustainable industry that **supports jobs, manufacturing**, and the **circular economy** in a wide range of applications

# SETO Funds 375+ Active Projects

Projects and partners in **48** states plus the **District of Columbia**

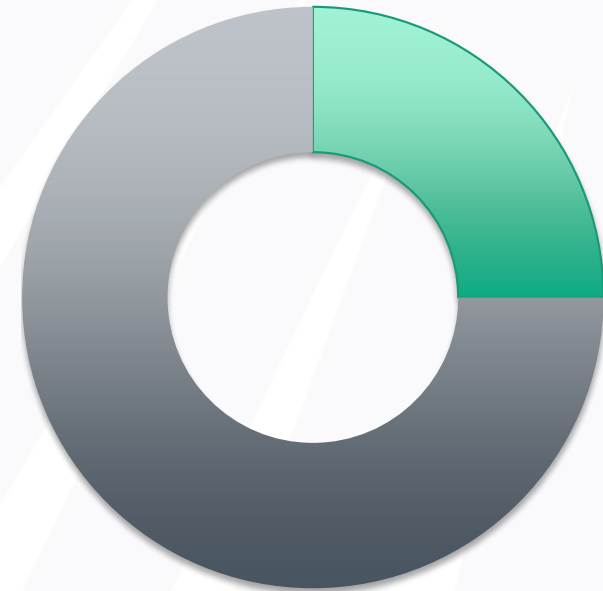
**40%** of projects led by **national labs**



**35%** of projects led by **universities**



**25%** of projects led by **businesses, non-profits, and state and local government**

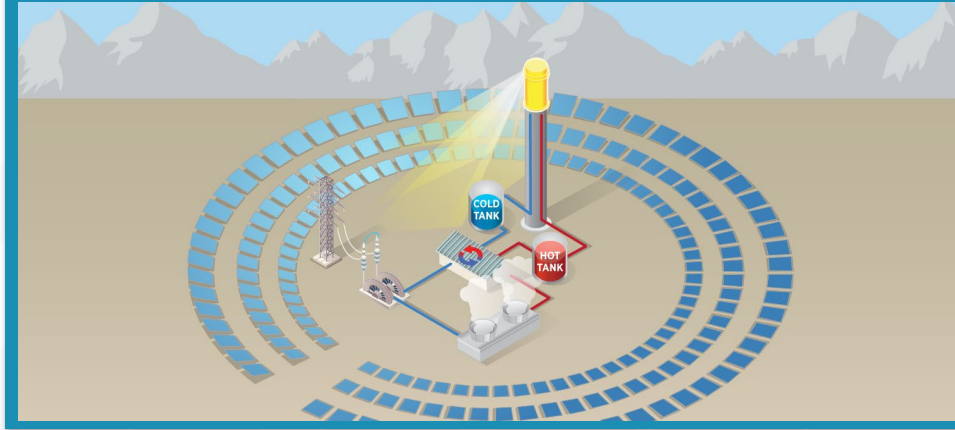


# SETO Teams

## PHOTOVOLTAICS



## CONCENTRATING SOLAR-THERMAL POWER



## STRATEGIC ANALYSIS AND INSTITUTIONAL SUPPORT



## SYSTEMS INTEGRATION



## MANUFACTURING AND COMPETITIVENESS



# Solar Energy Technologies Office Leadership Team



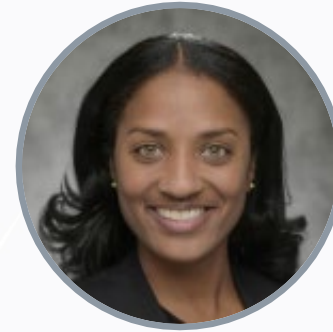
Dr. Becca Jones-Albertus  
*Director*



Garrett Nilsen  
*Deputy Director*



Dr. Elaine Ulrich  
*Senior Advisor*



Ebony Brooks  
*Operations Supervisor*



Dr. Lenny Tinker  
*Photovoltaics  
Program Manager*



Dr. Avi Shultz  
*Concentrating Solar-Thermal  
Power Program Manager*



Dr. Guohui Yuan  
*Systems Integration  
Program Manager*



Victor Kane  
*Acting Manufacturing  
and Competitiveness  
Program Manager*



Michele Boyd  
*Strategic Analysis and  
Institutional Support  
Program Manager*

# Solar Energy Technologies Office Leadership Team



Dr. Becca Jones-Albertus  
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Michele Boyd  
*Strategic Analysis and  
Institutional Support  
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# Today's Webinar

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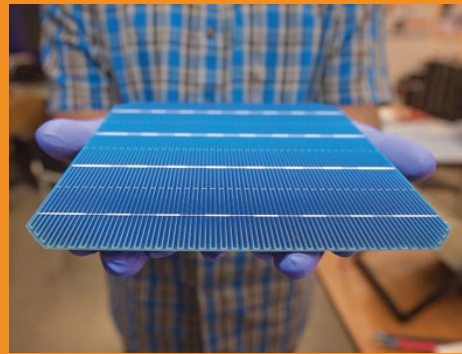
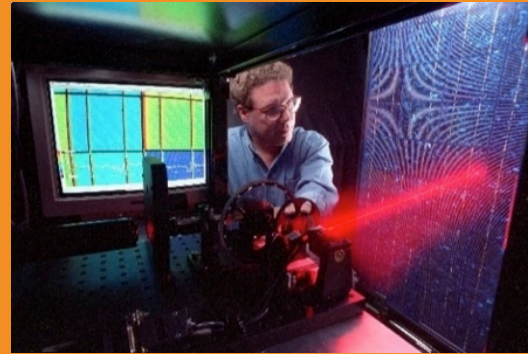
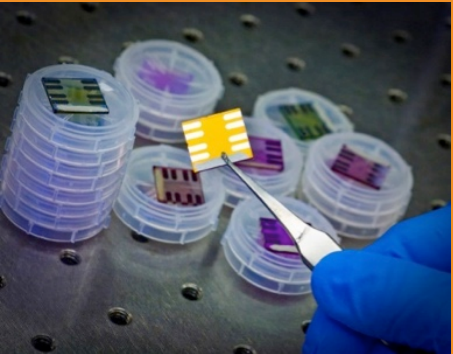
- SETO Updates
- SETO Photovoltaics Research Portfolio Overview
- Featured Awardee: Robert Flottemesch from Constellation on PV Fleet Performance Data Initiative
- Recording, slides, and links will be available on the [SETO webinars page](#)



U.S. DEPARTMENT OF  
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& RENEWABLE ENERGY

SOLAR ENERGY TECHNOLOGIES OFFICE



# SETO Updates

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[energy.gov/solar-office](https://energy.gov/solar-office)



# American-Made Solar Prize

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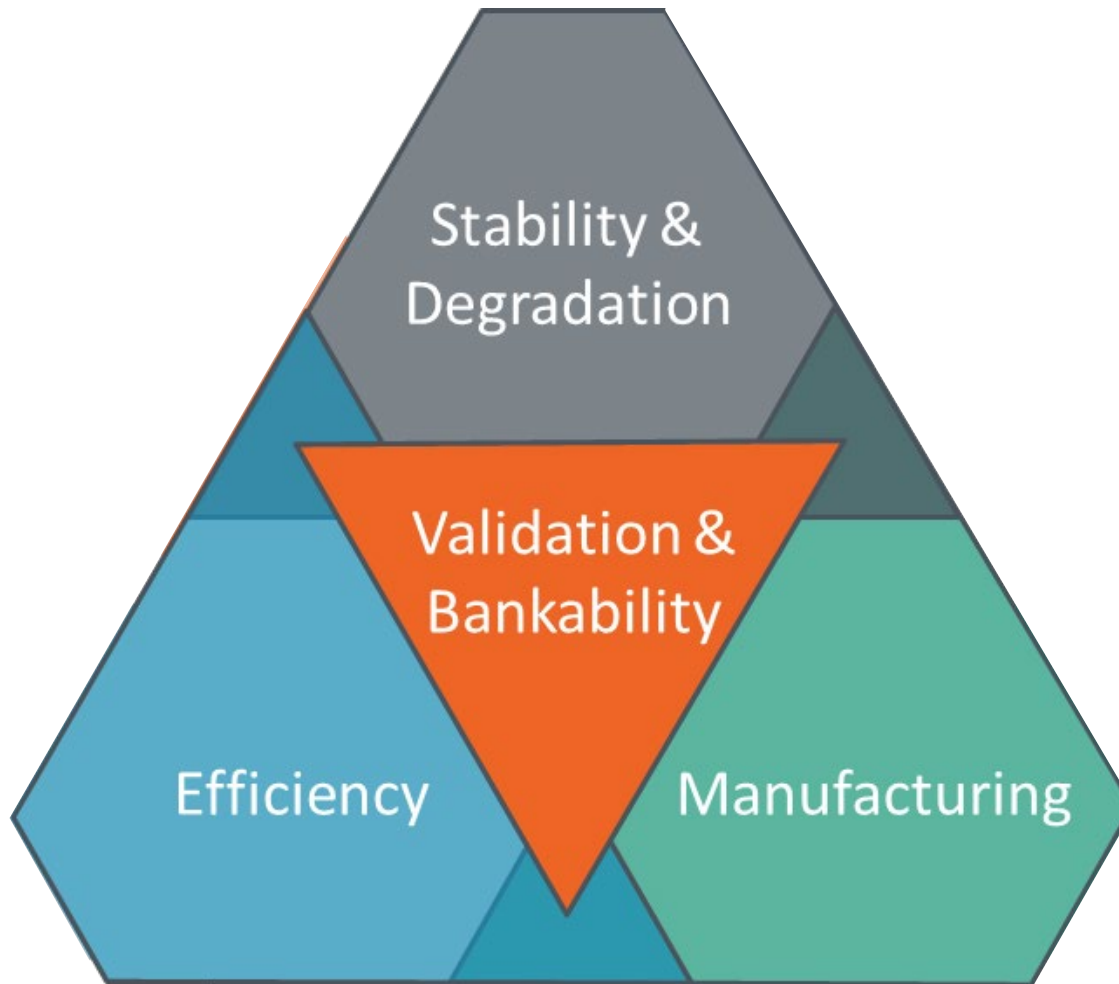


U.S. DEPARTMENT OF ENERGY

- **Round 2: Winners Chosen on August 28**
  - Resilient Power Systems (Georgetown, TX)
  - SunFlex Solar (Tempe, AZ)
  - \$500k grand prize, \$75k in technical assistance
- **Round 3: Finalists Chosen on July 10**
  - These 10 teams will compete at a final demo day in December 2020
- **Round 4: Deadline to enter is October 8**
  - Launched July 10

# Perovskite Funding Opportunity Announcement (FOA)

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- **\$20 million** in funding for projects that will advance perovskite photovoltaics
- Submit concept papers by **September 23**

# Solar Small Business Innovation Research (SBIR) Funding

- **July 14:** Eleven small solar companies awarded a combined **\$12.3 million** to develop prototypes of their new solar technologies
- Encourage U.S.-based small businesses to engage in high-risk, innovative R&D with commercialization potential



- Two types of SBIR funding awarded annually:
  - Phase I: Proof-of-Concept Development
  - Phase II: Prototype Development

# Technology Commercialization Fund (TCF)

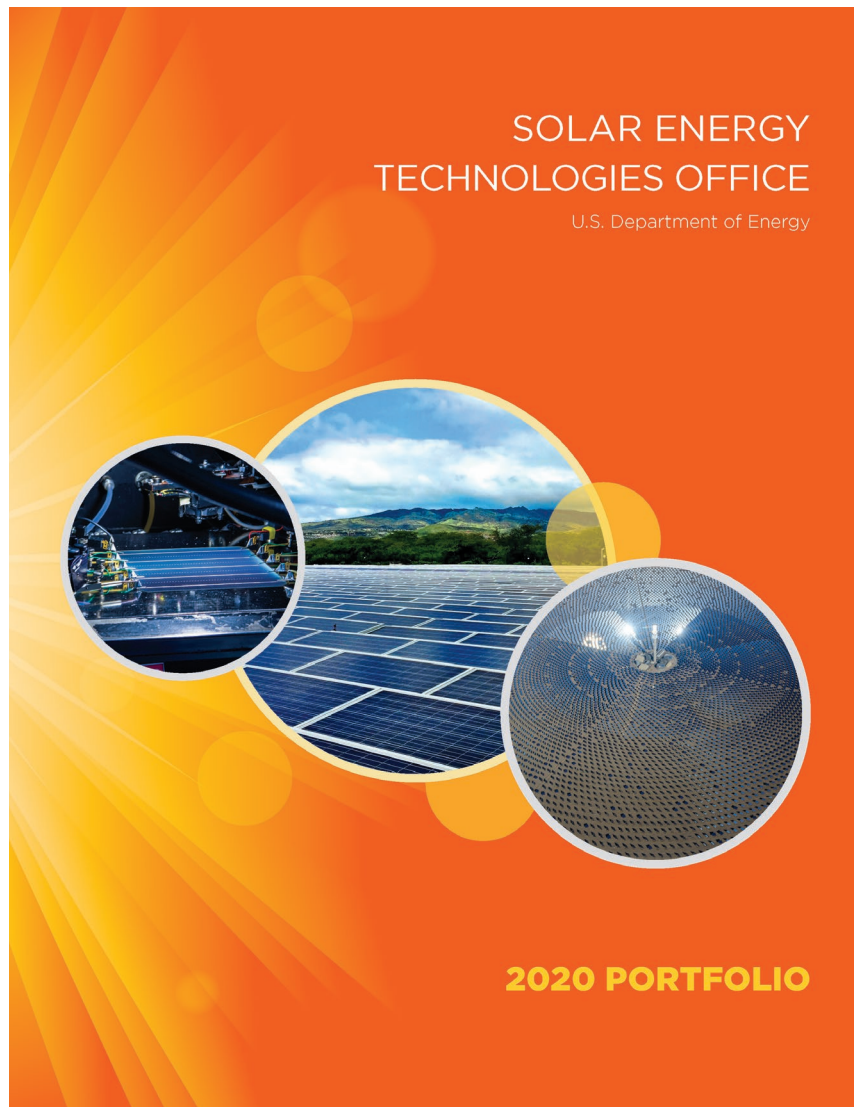
## Technology Commercialization Fund

U.S. DEPARTMENT OF  
**ENERGY**

Office of  
**TECHNOLOGY  
TRANSITIONS**

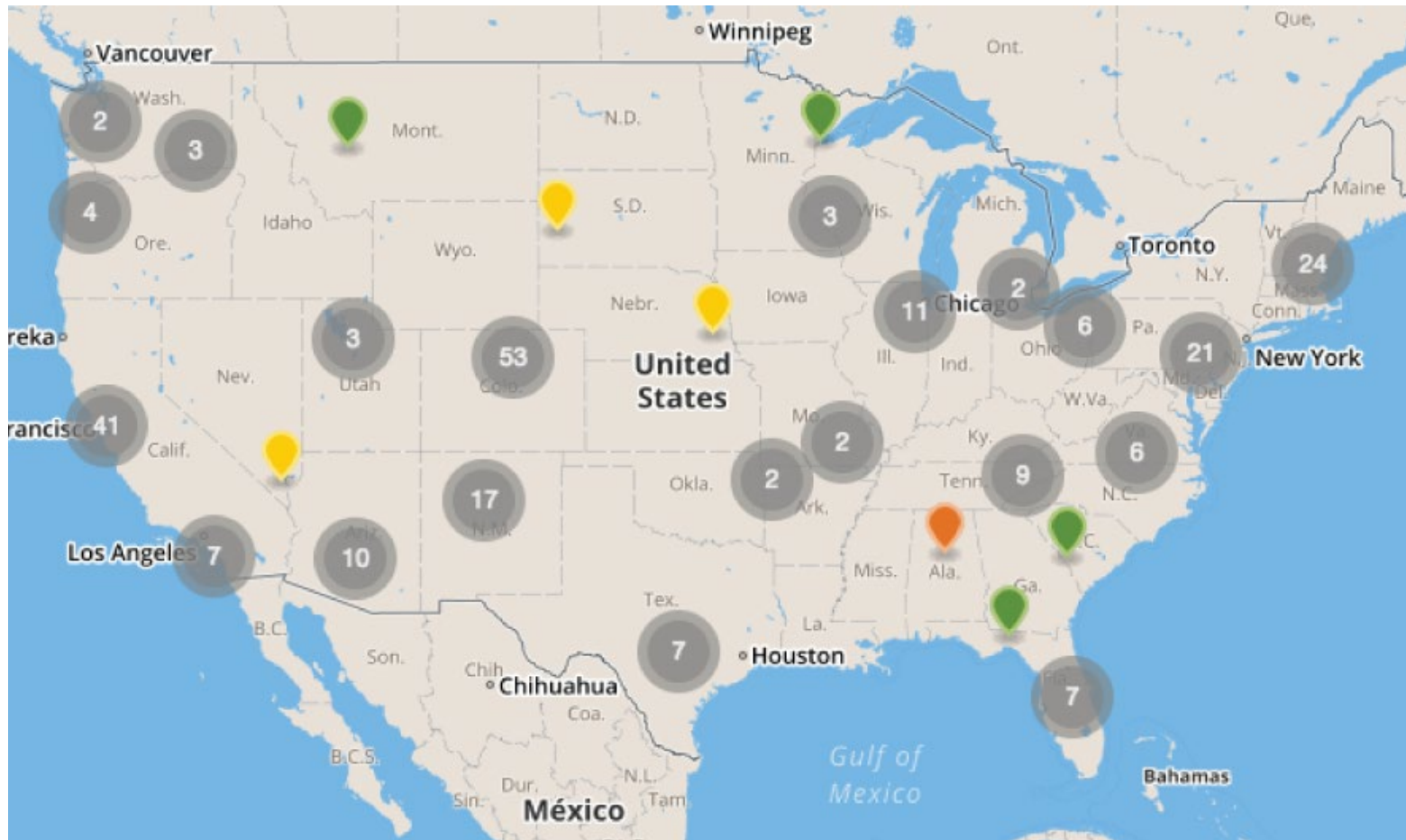
- **June 11:** Seven companies partnered with national labs to bring new solar technologies to market
- SETO awarded nearly **\$2.5 million**, which was matched by the companies
- Idaho National Laboratory and Inergy Holdings
- National Renewable Energy Laboratory (NREL) and First Solar
- NREL and 1366 Technologies
- NREL and Tandem PV
- NREL and Hyperlight Energy
- Sandia National Laboratories and SunSpec Alliance
- Sandia National Laboratories and Heliogen

# 2020 SETO Peer Review Report Released



- Results of SETO’s first all-virtual peer review, held April 6–8
- Identifies new strategies for SETO to meet and exceed its core objectives
- Based on high-level feedback from key stakeholders across SETO’s portfolio

# Solar Projects Map and Research Database



- Includes nearly 350 active projects and 1,200+ concluded projects
- Searchable and includes detailed project information

# Provide your Feedback on our Website

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- SETO is in the process of updating its website
  - Do you find particular content on our website useful?
  - Are we missing something that you would like more information on?
  - Email [gregory.obrien@ee.doe.gov](mailto:gregory.obrien@ee.doe.gov) with any comments by September 18

# Upcoming at SETO

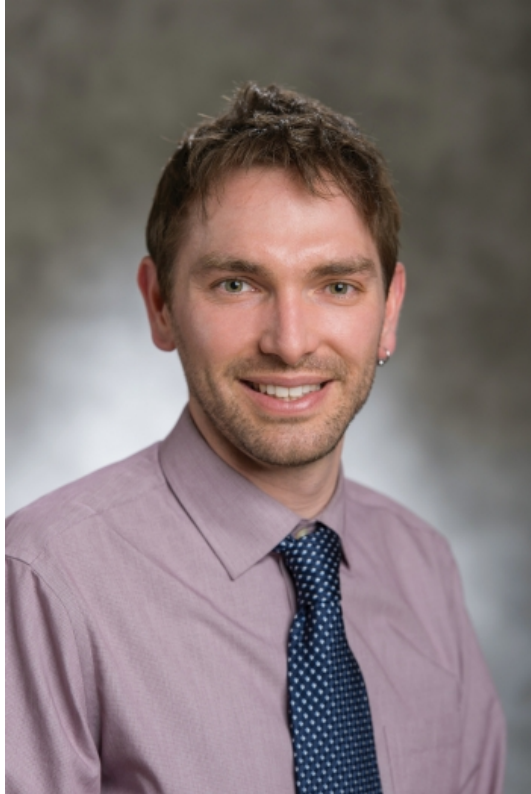
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- **Deadlines:**
  - **September 23:** Perovskite FOA concept paper deadline
  - **October 8:** American-Made Solar Prize Round 4 submissions due
- **Announcements:**
  - EMPOWERED selections
  - Solar Desalination Prize competitors
  - FY2020 FOA selections



# QUESTIONS?

Please use the chat feature  
to ask your questions.



# Photovoltaics

Dr. Lenny Tinker

Program Manager, Photovoltaics

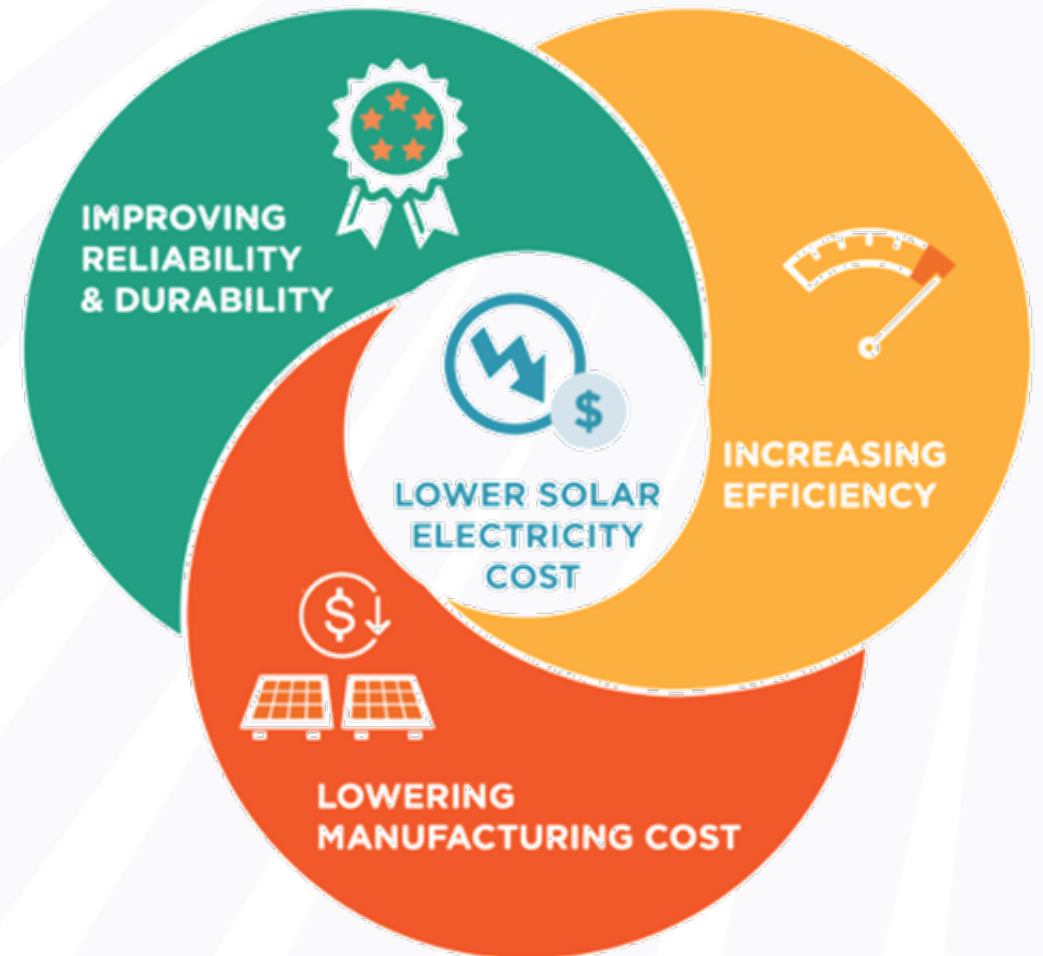
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# SETO Photovoltaics R&D Approach

Funds research with a 3-15 year horizon, which is beyond industry focus or capabilities

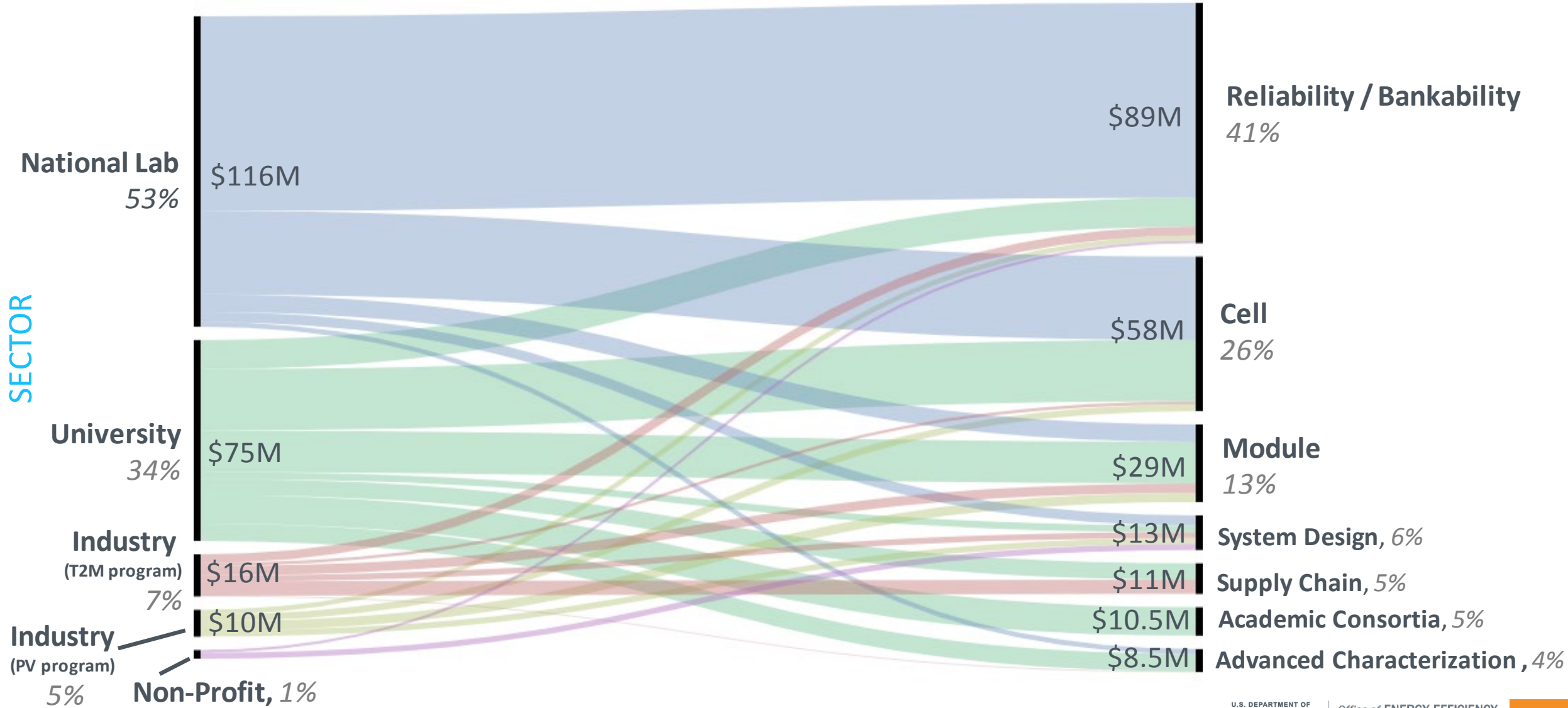
Supports an innovation ecosystem that includes universities, students, professors, and the private sector

Fosters the transition of research developments into the marketplace

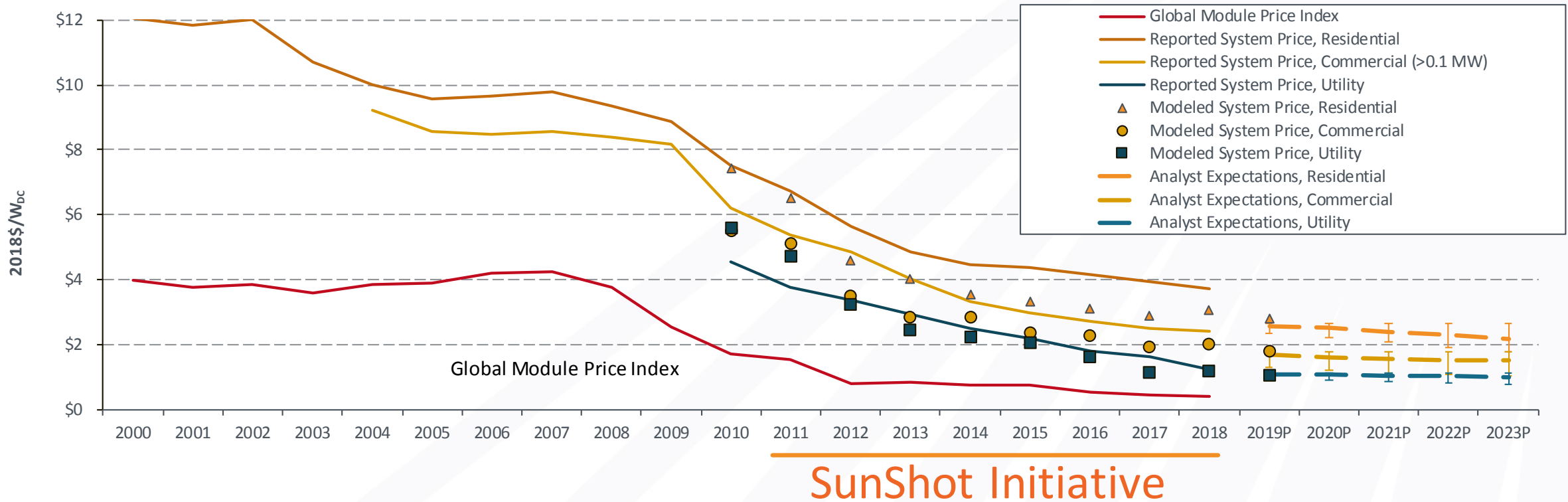


# SETO PV Research Funding Allocation - 2020

(\$219M spanning multiple years)



# A Brief Perspective on SETO PV R&D History



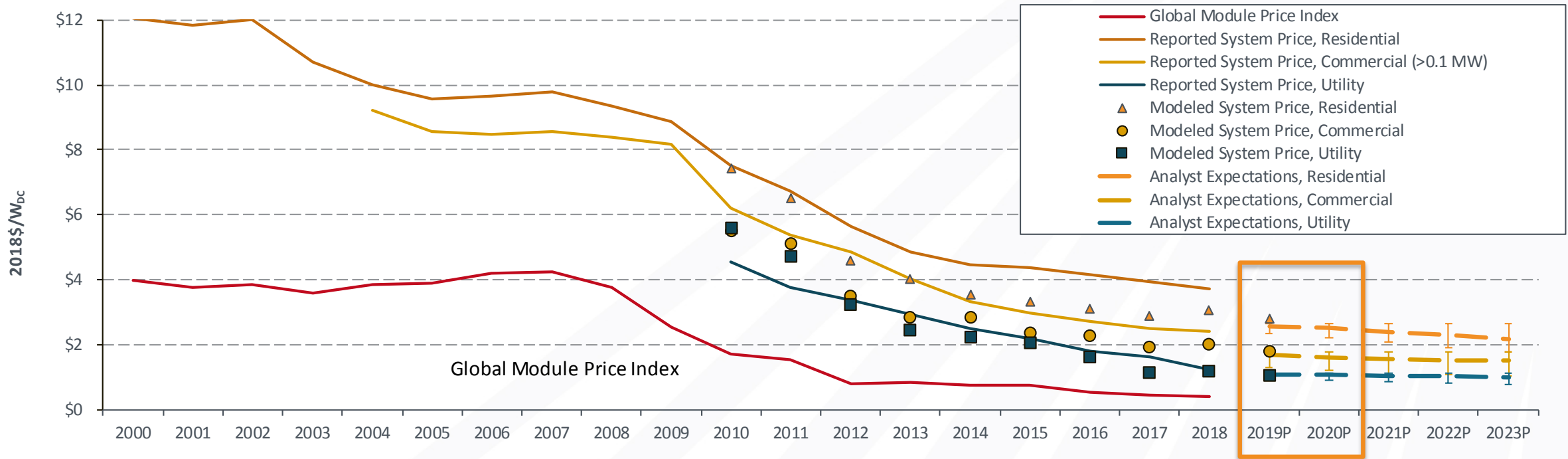
## Where we've been:

- PV was prohibitively expensive
- Set SunShot goal: \$0.06 per kilowatt-hour for utility-scale systems

**Note:** Reported prices represent the median national U.S. averages. Error bars represent the high and low analyst expectations.

**Sources:** Reported residential and commercial system prices (Barbose and Darghouth 2019); reported utility system prices (Bolinger, Seel, and Robson 2019); modeled system prices (Feldman, Fu, Ramdas, Desai, and Margolis 2019); analyst expectations (NREL 2019 Annual Technology Baseline); The Global Module Price Index is the average module selling price for the first buyer (P. Mi nts SPV Market Research).

# A Brief Perspective on SETO PV R&D History



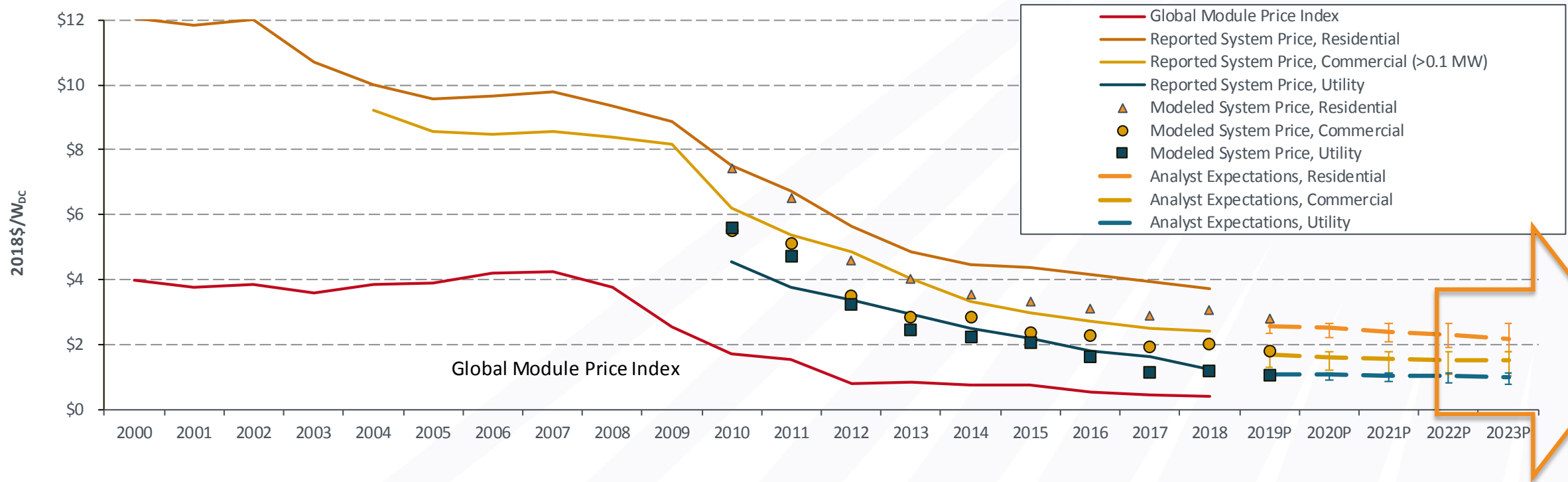
## Where we are:

- Achieved SunShot goal in 2017
- 3% US electricity met by PV

**Note:** Reported prices represent the median national U.S. averages. Error bars represent the high and low analyst expectations.

**Sources:** Reported residential and commercial system prices (Barbose and Darghouth 2019); reported utility system prices (Bolinger, Seel, and Robson 2019); modeled system prices (Feldman, Fu, Ramdas, Desai, and Margolis 2019); analyst expectations (NREL 2019 Annual Technology Baseline); The Global Module Price Index is the average module selling price for the first buyer (P. Mi nts SPV Market Research).

# A Brief Perspective on SETO PV R&D History



## Where we're going:

- Set a 2030 \$0.02/kWh target for areas of US with modest insolation
- Low incremental value of PV at the sunniest times of day

**Note:** Reported prices represent the median national U.S. averages. Error bars represent the high and low analyst expectations.

**Sources:** Reported residential and commercial system prices (Barbose and Darghouth 2019); reported utility system prices (Bolinger, Seel, and Robson 2019); modeled system prices (Feldman, Fu, Ramdas, Desai, and Margolis 2019); analyst expectations (NREL 2019 Annual Technology Baseline); The Global Module Price Index is the average module selling price for the first buyer (P. Mi nts SPV Market Research).

# Solar-Storage Synergy

MORE STORAGE = MORE SOLAR

## Solar increases market opportunity for storage:

Narrows the net load peak, increasing market size and reducing hours of storage needed

DC-coupled solar plus storage is cheaper than solar or storage deployed independently

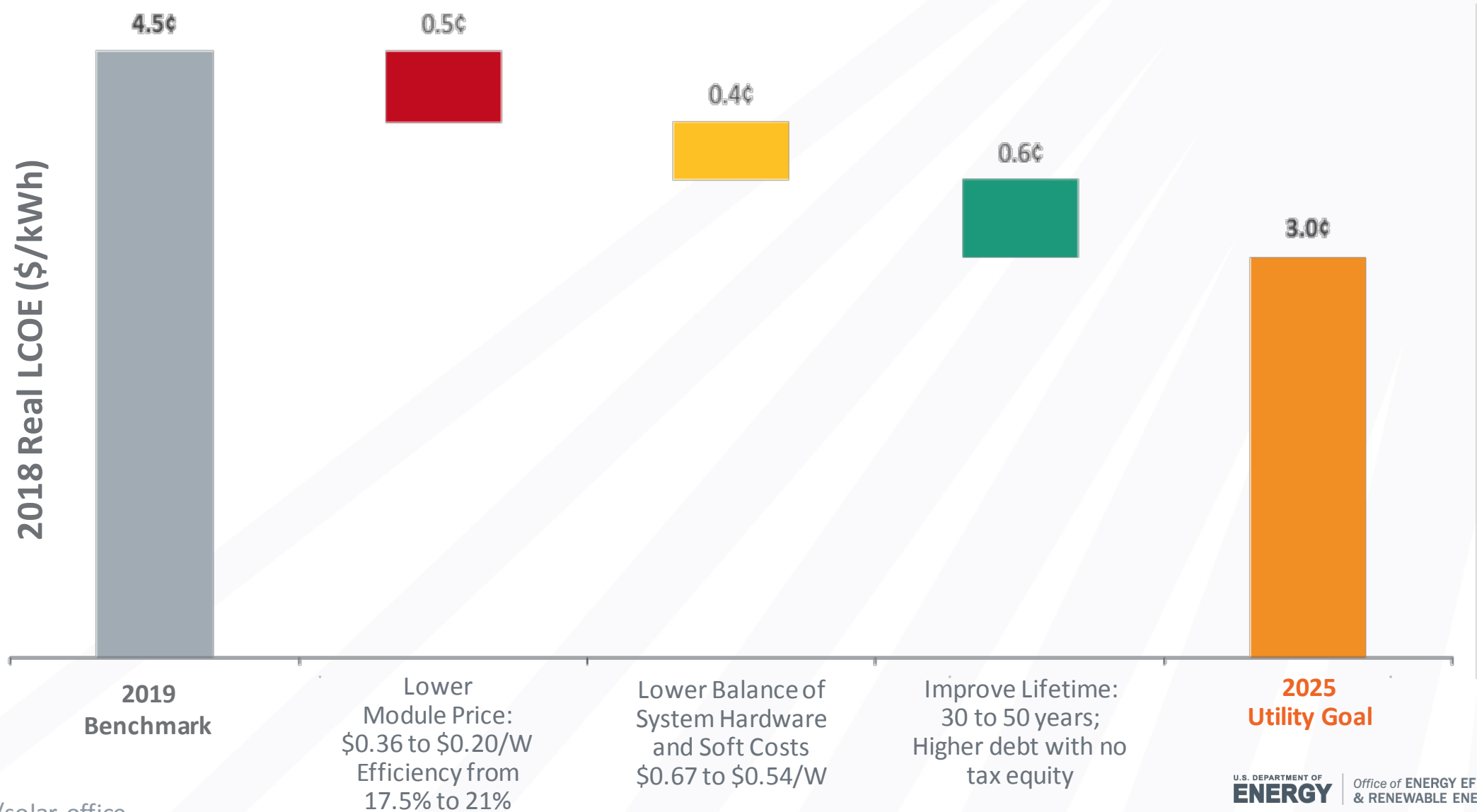
## Storage increases market opportunity for solar:

Provides sink for curtailed solar

MORE SOLAR = MORE STORAGE

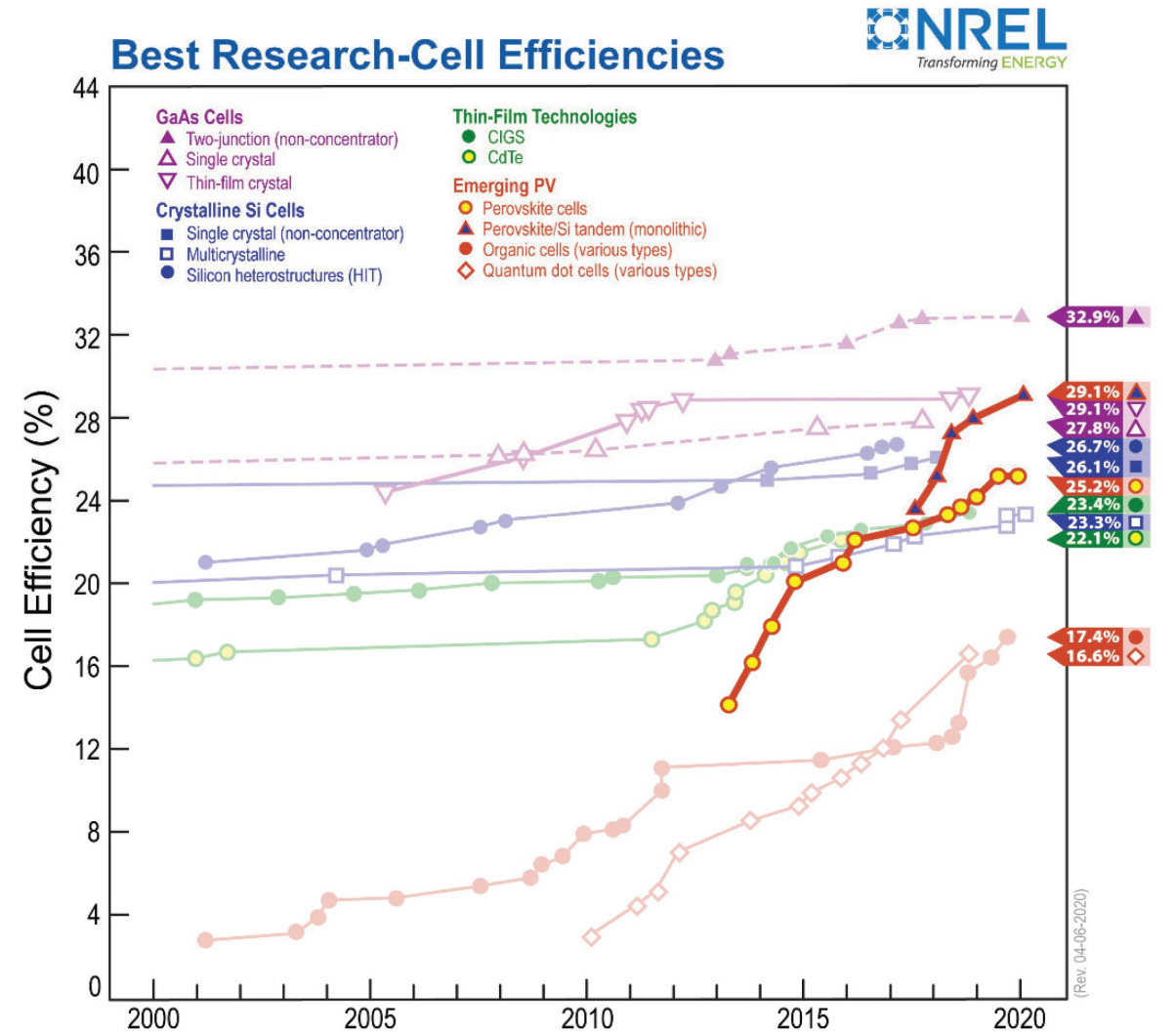


# A Pathway to \$0.03 per kWh for Utility-Scale PV



# New Photovoltaic Technologies

- New absorber materials
- New device architectures (ex: tandem)
- Create new U.S. PV manufacturing capacity based on technology not yet commercialized



# Dual Land Use

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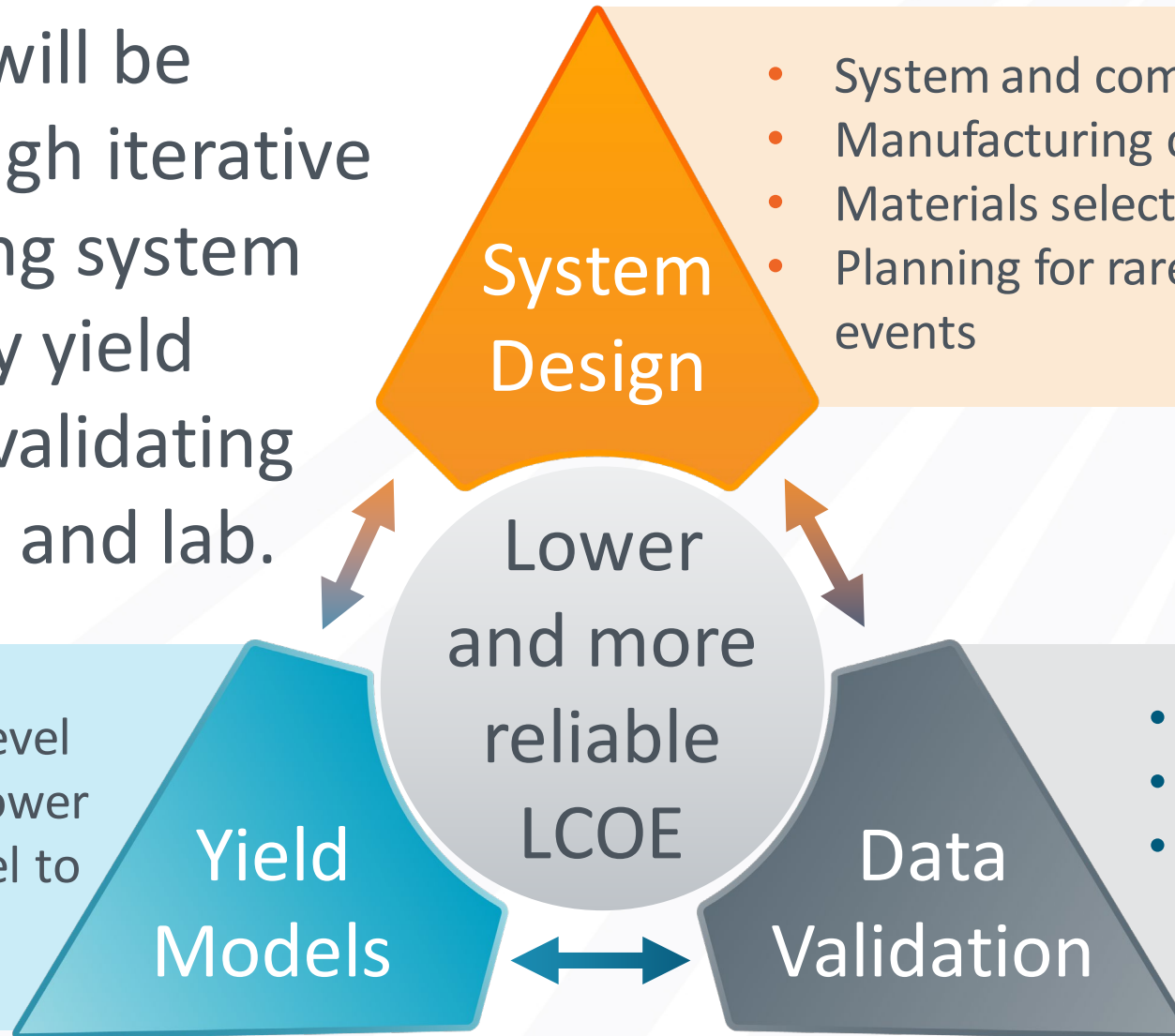
- Agrivoltaics
- Floatovoltaics
- Building-Integrated Photovoltaics
- Enable dual-use through new modeling tools, materials and hardware designs, and field data characterization



# SETO PV Reliability Portfolio Approach

Improvement will be achieved through iterative feedback among system designs, energy yield modeling and validating data from field and lab.

- Performance at fleet level
- System and module power
- Modeling at micro level to predict lifetime

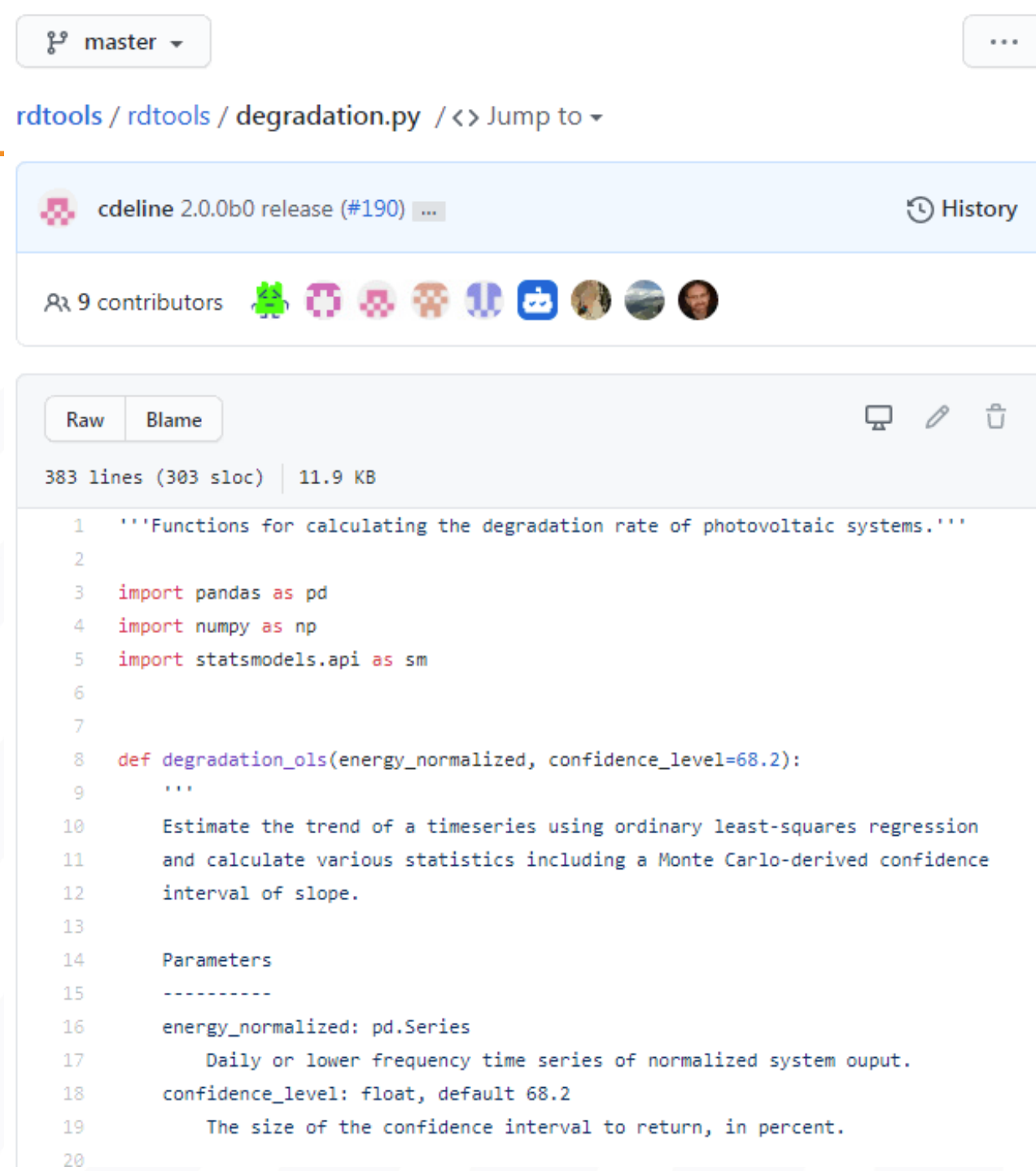


- Outdoor long-term data
- O&M experiences
- Laboratory validation and accelerated tests

# RD Tools

- Open source Python scripts and software for analysis of photovoltaic time-series data
- Used to calculate annual degradation rates and confidence intervals

<https://www.nrel.gov/pv/rdtools.html>

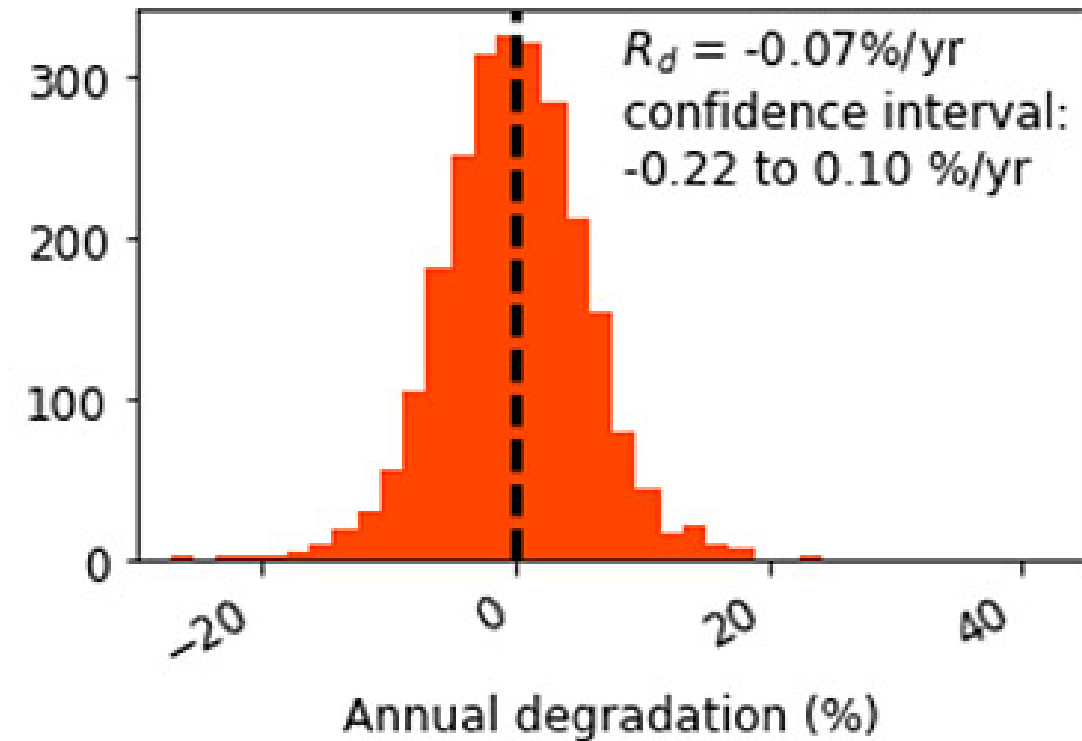
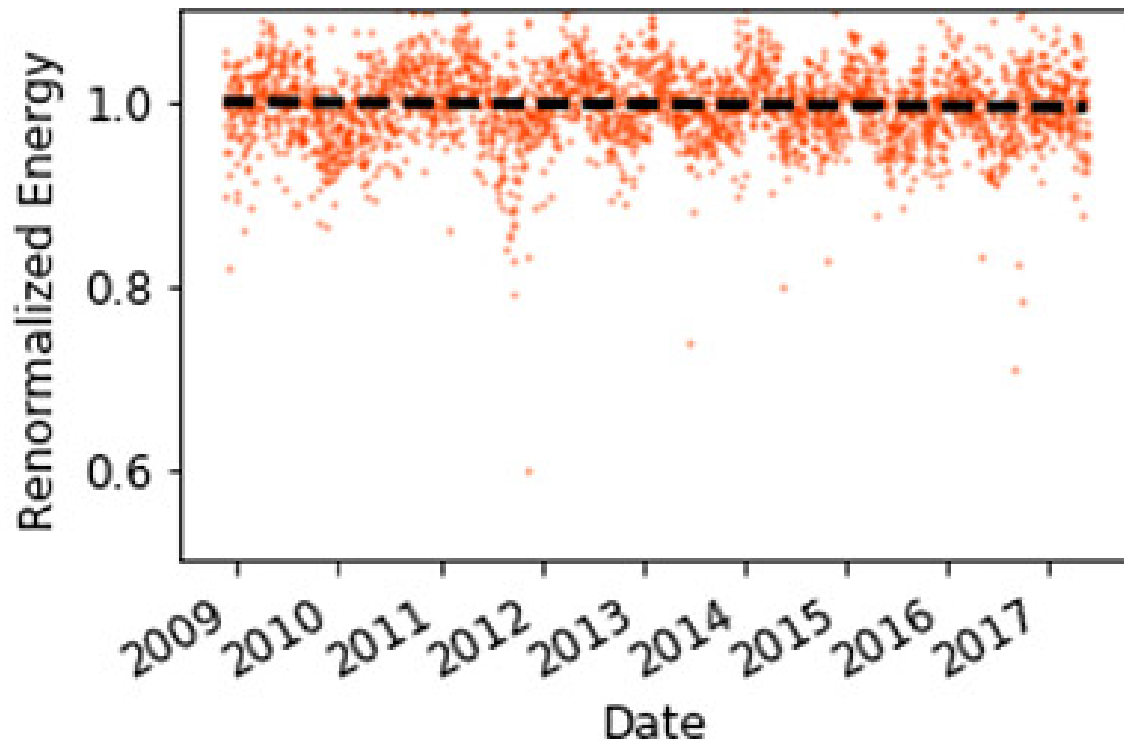


The screenshot shows a GitHub repository for 'rdtools' on the 'master' branch. The file 'degradation.py' is selected, showing its commit history and contributors. The file content is displayed in a code editor with the following Python code:

```
1 '''Functions for calculating the degradation rate of photovoltaic systems.'''
2
3 import pandas as pd
4 import numpy as np
5 import statsmodels.api as sm
6
7
8 def degradation_ols(energy_normalized, confidence_level=68.2):
9     ...
10     Estimate the trend of a timeseries using ordinary least-squares regression
11     and calculate various statistics including a Monte Carlo-derived confidence
12     interval of slope.
13
14     Parameters
15     -----
16     energy_normalized: pd.Series
17         Daily or lower frequency time series of normalized system output.
18     confidence_level: float, default 68.2
19         The size of the confidence interval to return, in percent.
20
```

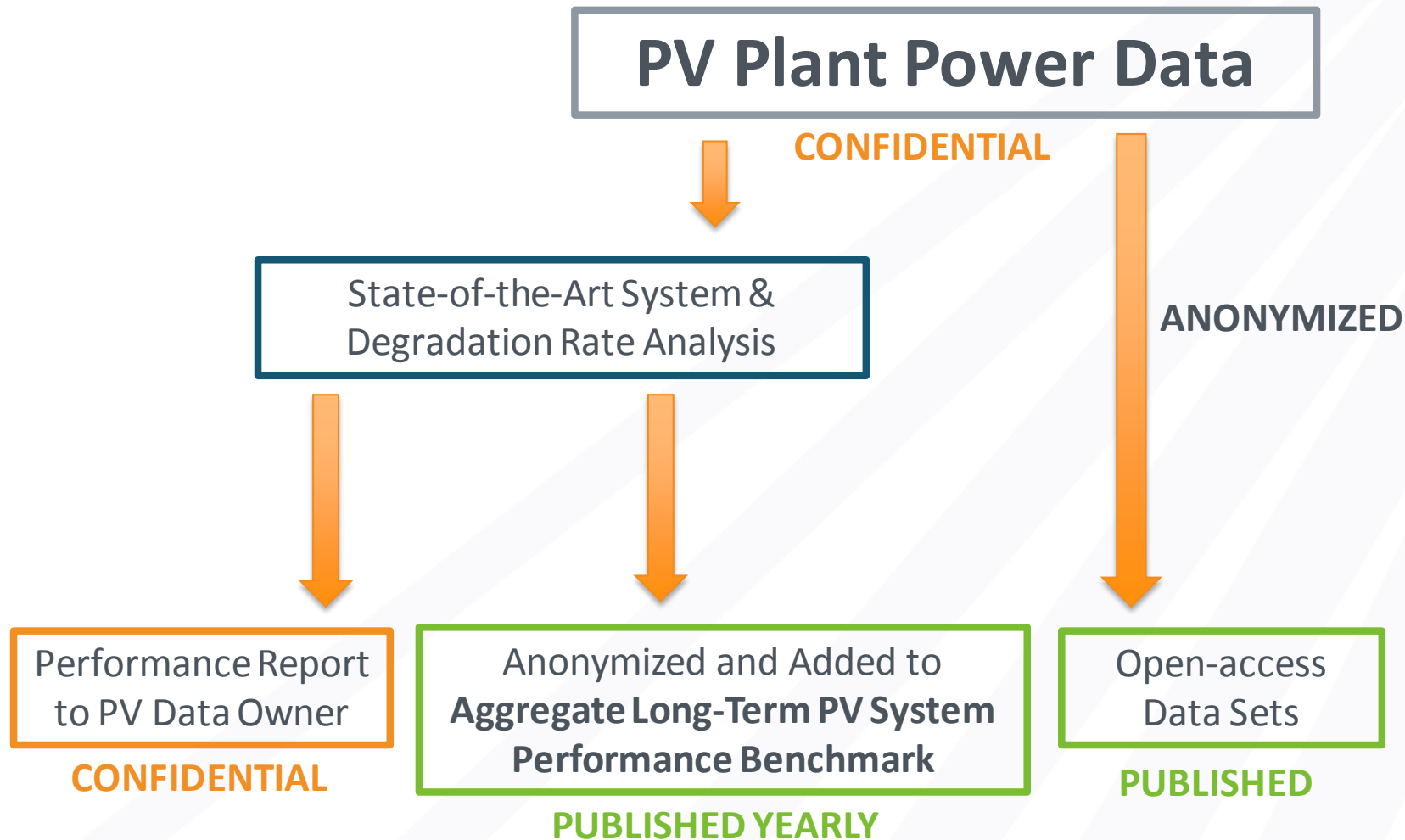
# RD Tools

## Clear-sky-based degradation results



<https://www.nrel.gov/pv/rdtools.html>

# DOE PV Fleet Performance Data Initiative



# DOE PV Fleet Performance Data Initiative

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## Any PV Plant performance data owner can participate

(analysis time is dependent on NREL availability)

### What data is needed?

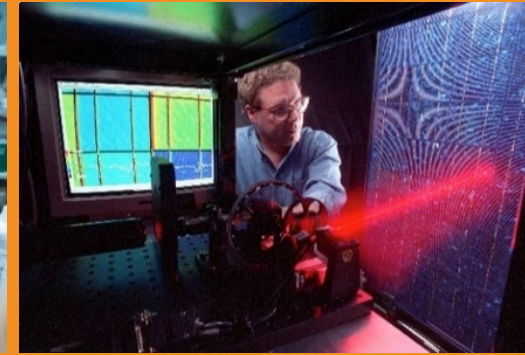
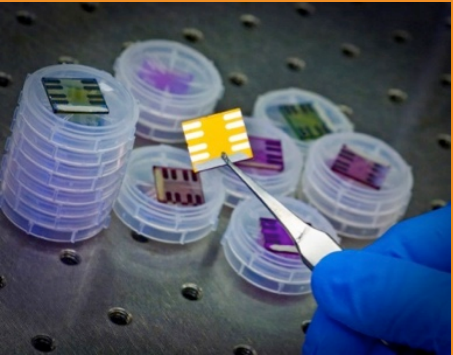
- Time-series PV system power output for large-scale installations (>250 kW) for  $\geq 5$  years collected at 1-15 min intervals, with
- On-site irradiance and meteorological data
- “Metadata” (type of PV modules, location, mounting, azimuth and tilt)

**Confidentiality** of data protected via standardized NDA agreements.



# QUESTIONS?

Please use the chat feature  
to ask your questions.



# Photovoltaic Fleet Performance Data Initiative

---

Robert Flottemesch  
Constellation

# DOE/SETO: PV Fleets

## Industry Observations

Robert Flottemesch

September 10, 2020



**Constellation**<sup>®</sup>

An Exelon Company

# About Exelon

# Exelon's Family of Companies

Exelon's family of companies represents every stage of the energy value chain.



## Generation

### Exelon Generation

**Generation Capacity:**  
More than 31,000 MW



## Energy Sales & Services

### Constellation\*

**Competitive C&I Load Served:**  
213 Annualized TWH (power)  
1,540 Annualized BCF (natural gas)

**Competitive Energy Sales:**  
Approximately 2 million residential,  
public sector and business  
customers  
Wholesale sales, dispatch, and  
delivery from Exelon's ~31 GW  
power generation portfolio



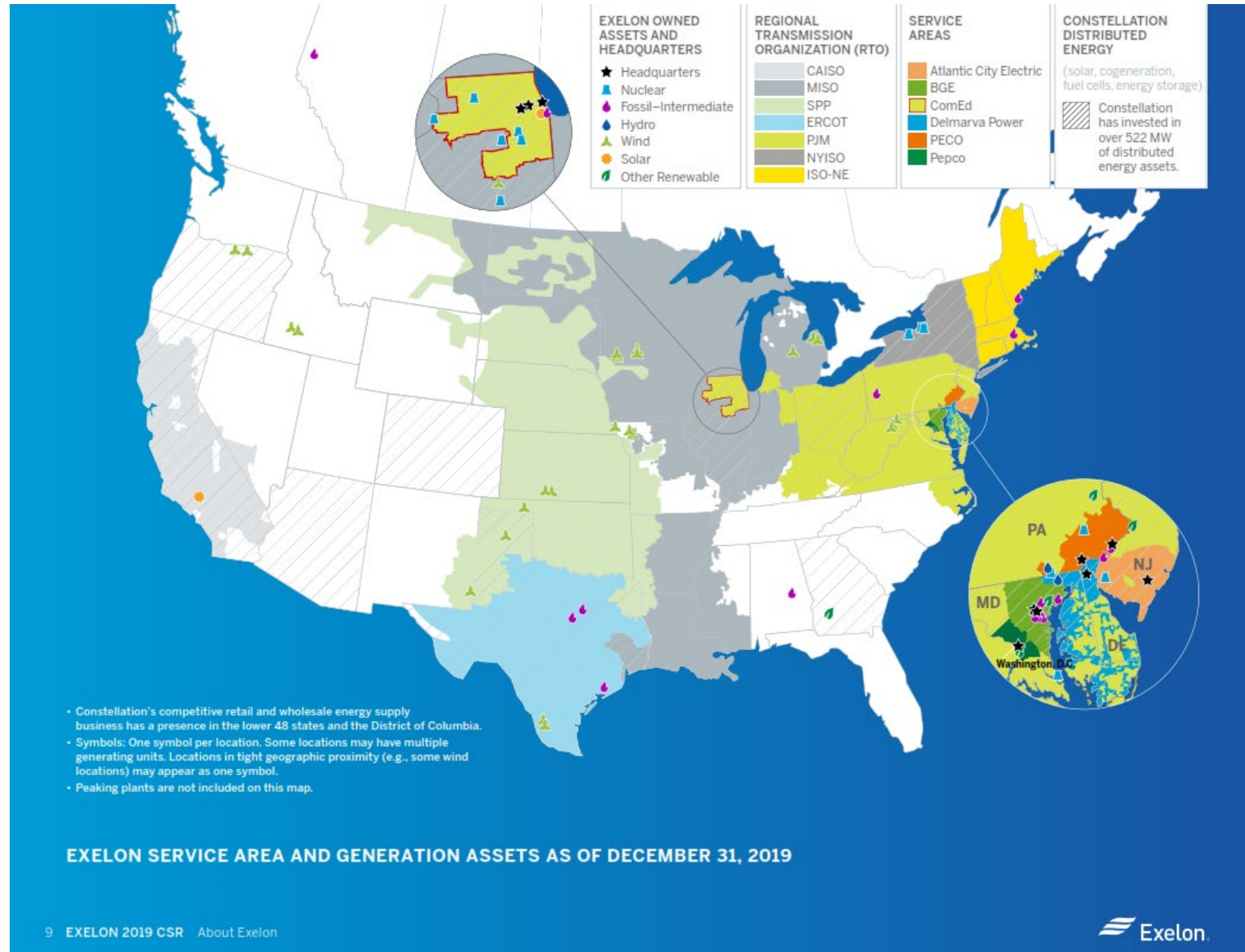
## Transmission & Delivery

**Atlantic City Electric,  
BGE, ComEd,  
Delmarva Power,  
PECO and Pepco**

**Service:**  
10 million electric and natural  
gas customers

\*Q1 2020 Data

# Exelon's Footprint



# About Constellation

# Constellation: Who, What & Where We Serve



**Natural Gas**  
Approx **784 Bcf**  
load in C&I markets<sup>^</sup>



**Retail Power**  
Approx **152 TWh**  
C&I load under contract<sup>^</sup>



**Energy Efficiency**  
Approx **613,000 MWh**  
Annual MWh Savings from EE  
and EME Programs



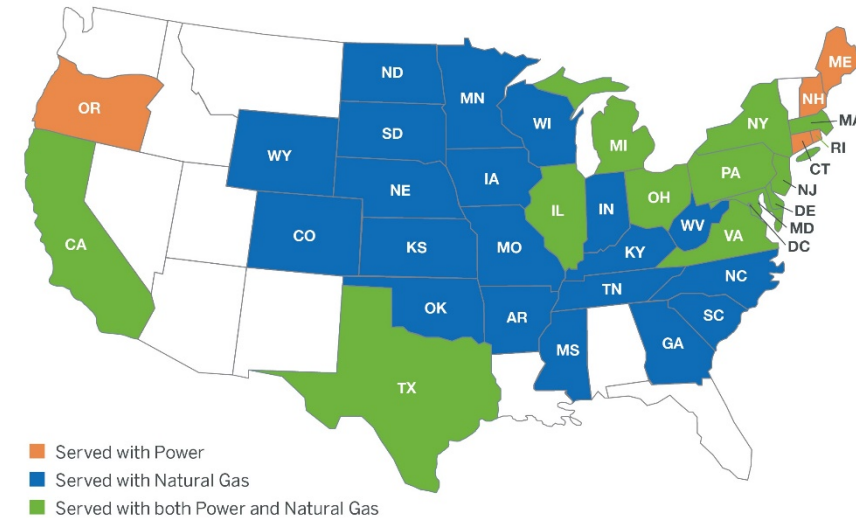
**Solar**  
**417 MW**  
customer sited,  
completed or under  
construction



**Distributed Generation**  
**65 MW**  
customer sited,  
completed or under  
construction

We serve approximately  
**2 million** customers,  
including  
**3/4 of the Fortune 100,**  
approximately  
**216,500 Business & Public Sector** customers,  
and  
about **1.6 million unique residential** customers.

We serve Power & Natural Gas across all competitive markets:



\*Q1 2020 Data



# Solar

---

**Constellation has over 400 MWs of distributed solar generation in operation or under construction at 620 sites across 15 states and the District of Columbia.**

**By hosting a solar system onsite, customers can:**

- Reduce overall energy costs
- Create energy price stability
- Provide energy reliability/resiliency
- Reduce carbon emissions
- Receive positive marketing value



# PV Fleets: Industry Observations

# Timeline

---

- **Jan 2016** – Sarah Kurtz and Dirk Jordan from NREL lead effort to develop [IEC 61724-4](#);
  - Constellation provides data set to aid standard development;
  - Variation in results observed when implementing draft standard;
- **Jan 2017** – Chris Deline from NREL presents results from early version of [Rd Tools](#);
  - YOY data closely aligns with lab degradation measurements of fielded modules;
- **Q1 2018** – Rd Tools [YOY Clear Sky](#) method Alpha integration into Also Energy platform complete;
  - NREL validates results from 10 sample sites;
  - [Rd Tools run for Constellation Fleet](#);
- **Q2 2018** – Constellation observed degradation rates that in some cases exceed 0.5%/year;
- **Q2 2018 thru Present** – Constellation conducts deeper investigation to validate results from Rd Tools and to identify root causes of degradation. Need for more industry context & degradation data;
- **April 2019** – [DOE SETO announces launch of PV Fleets](#);
- **April 2019 thru Present** – Constellation provides data to NREL through Also Energy API;
- **Oct 2019** – NREL provides Constellation a First Draft Report from PV Fleets;
- **Present** – Leverage insight towards robust [Quality Assurance & Technology Risk Mitigation Program](#)

# PV Fleets: Workflow

AWS database

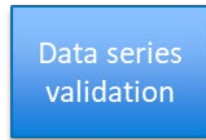
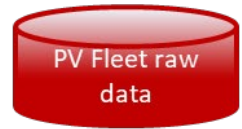
QA assessment

Analysis

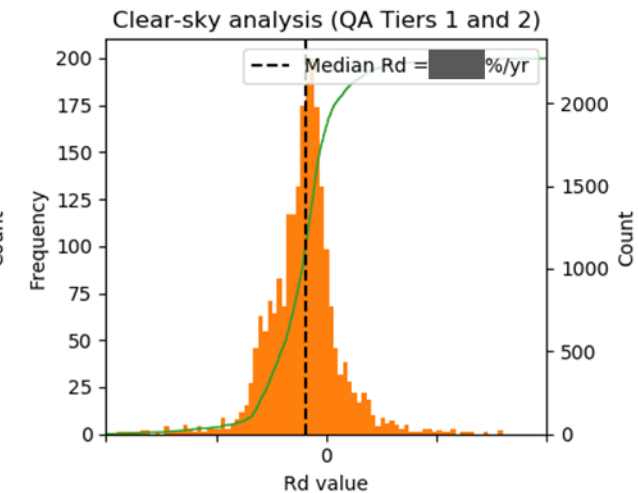
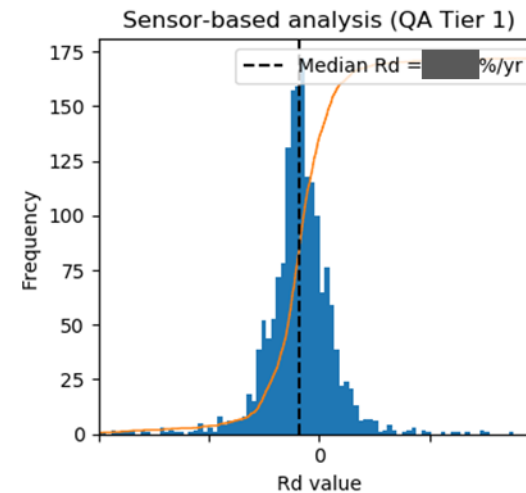
Reporting



Validated system & series data

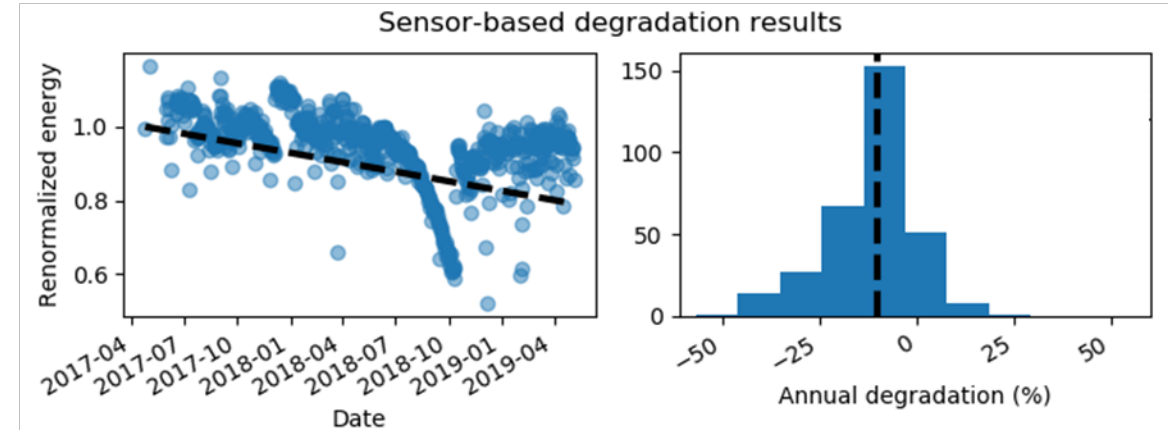
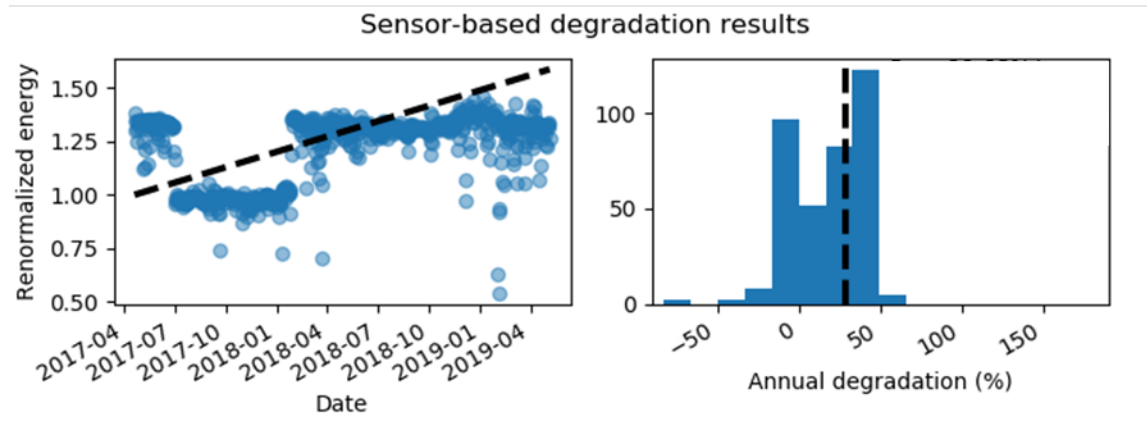
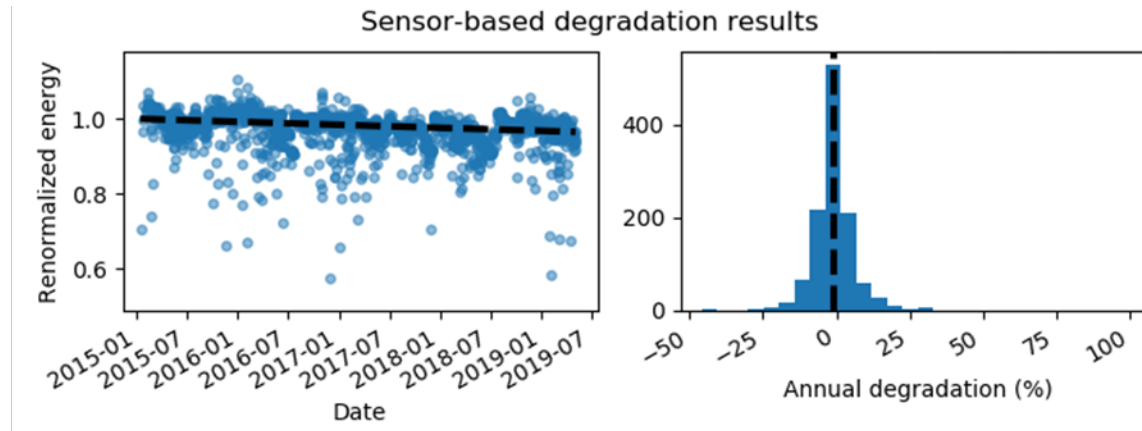


Special thanks to the supportive team at DOE/SETO for creating PV Fleets: [Inna Kozinsky](#), [Tassos Golnas](#), [Lenny Tinker](#), [Manav Sheoran](#), [Becca Jones-Albertus](#), and [Charlie Gay](#). Huge thank you to the intrepid team at NREL for all their hard work to provide Constellation a First Draft Report, PV Fleets: [Chris Deline](#), [Matt Muller](#), [Michael Deceglie](#), [Dirk Jordan](#), [Kevin Anderson](#), [Lin Simpson](#), [Kirsten Perry](#), [Robert White](#), and [Teresa Barnes](#).



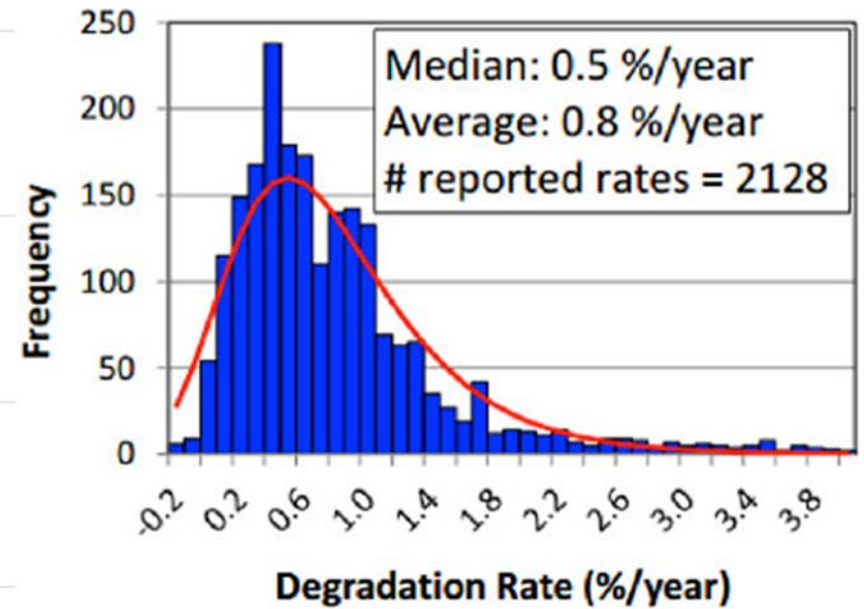
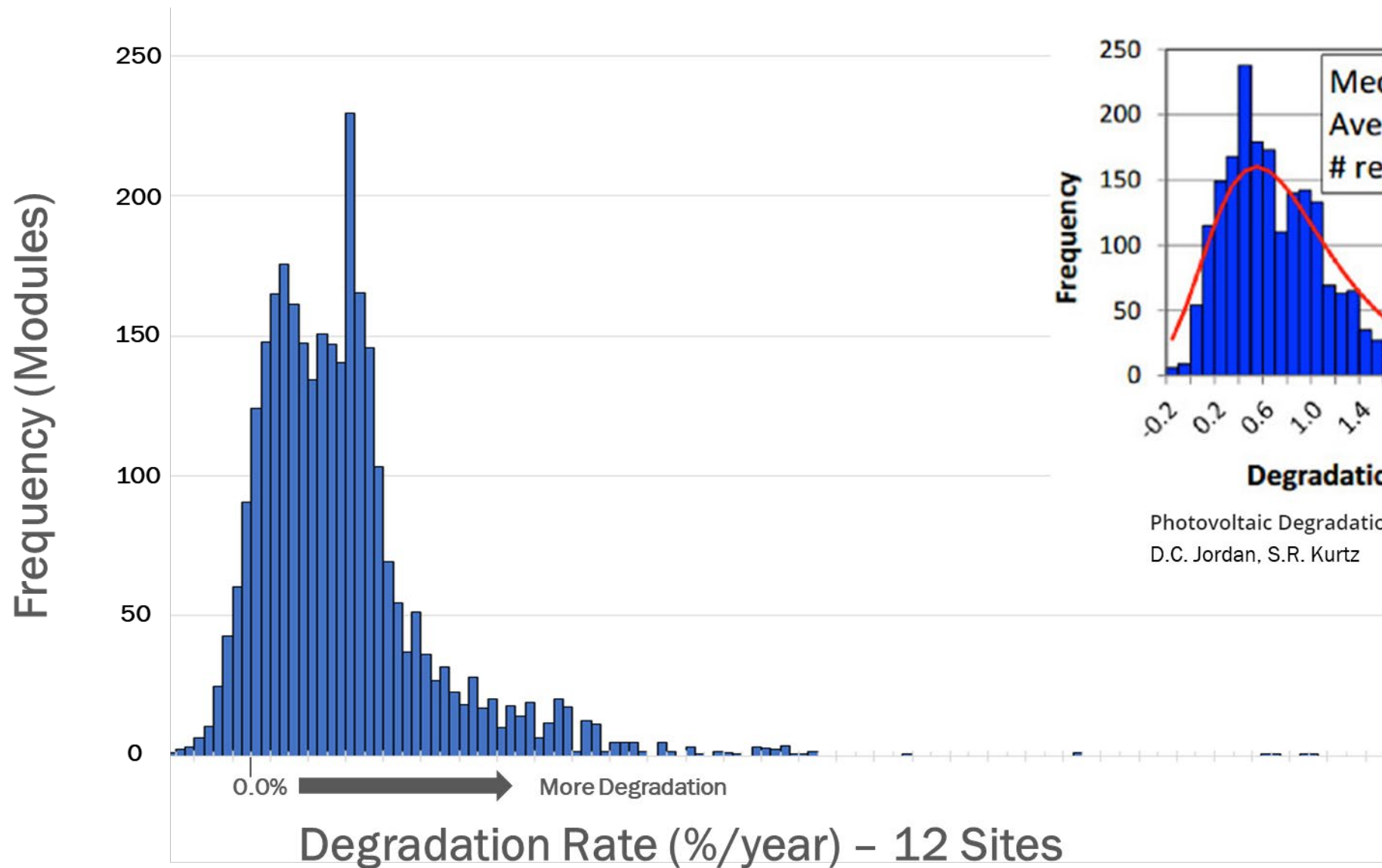
Example Figures of Constellation Fleet from Draft Report, PV Fleets

# Individual Site Examples



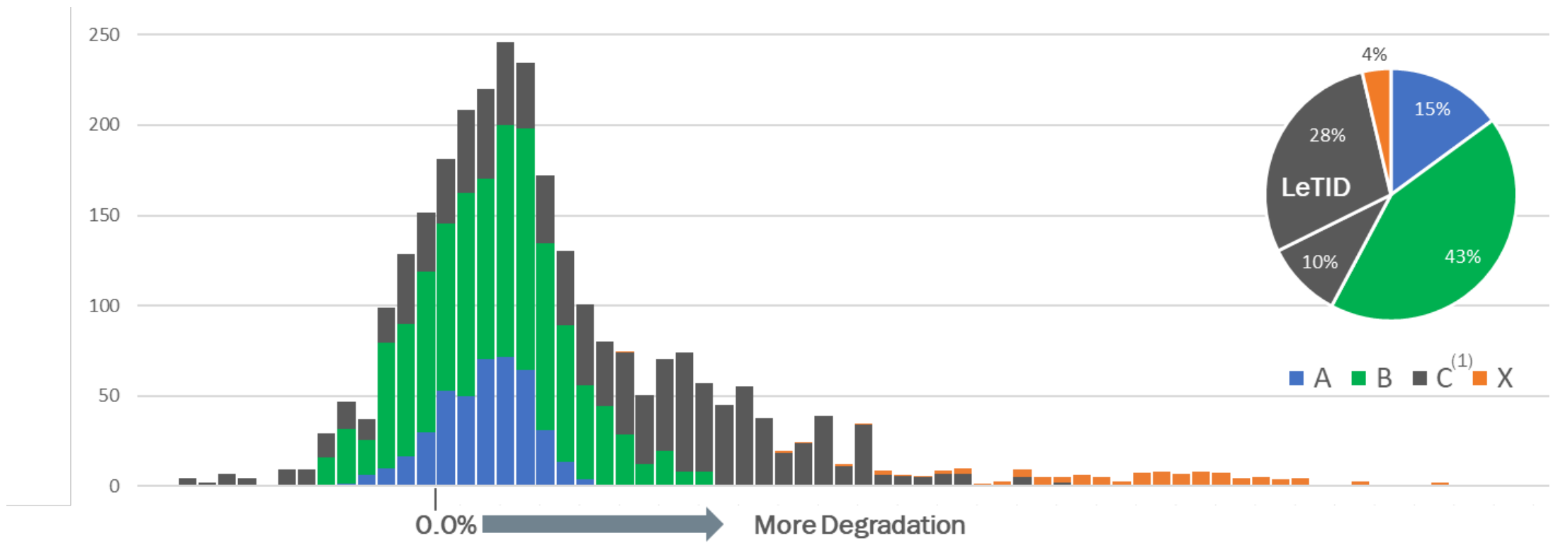
Draft Report, PV Fleets: Chris Deline, Matt Muller, Michael Deceglie, Dirk Jordan, Kevin Anderson, Lin Simpson, Kirsten Perry and Robert White

# Field Testing Results



Photovoltaic Degradation Rates—an Analytical Review  
D.C. Jordan, S.R. Kurtz

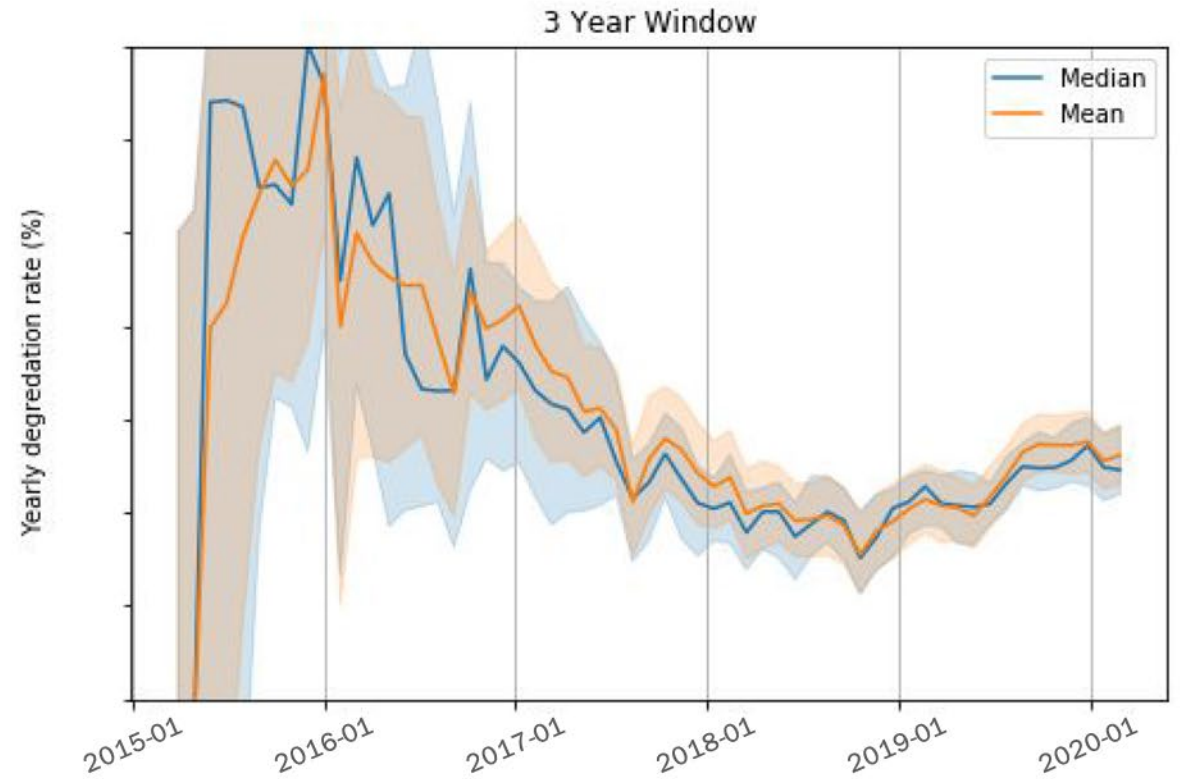
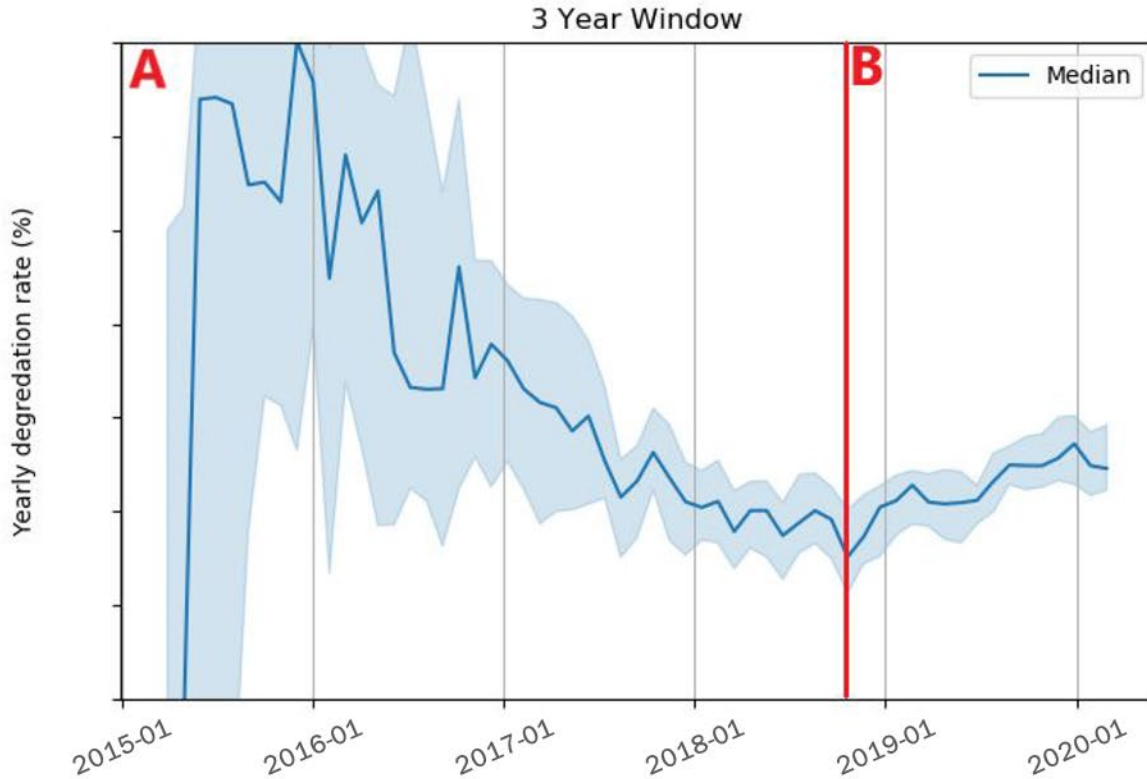
# Module Degradation Class



- A Top Performance: Brand Z, Brand Y, early Brand X (pre-2014).
- B Solid Performance: Brand T, early Brand W, and Brand V. Minimum target for new module procurement.
- C<sup>(1)</sup> Mixed Performance: 2014-2017 Brand W & Brand X impacted by LeTID<sup>(2)</sup> plus a range of early technology and vendors.
- X Brand V technology, data represents initial stabilization period, significantly lower lifetime degradation expected.

(1) 28% of Class C modules impacted by LeTID and are now entering recovery phase where loss from LeTID will be regained. 10% represent the balance of Class C and are expected to maintain mixed performance. (2) Light and elevated Temperature Induced Degradation

# Fleet Degradation Evolution



The ability to measure inverter/site/fleet level degradation provides a powerful tool for disaggregation of energy losses that can be used to boost fleet generation which increases revenue. It also provides technology insight that helps mitigate proforma risk through improved model accuracy in tandem with identifying and then avoiding poor performing technology.



# Thanks for Listening

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Robert Flottemesch

[robert.flottemesch@constellation.com](mailto:robert.flottemesch@constellation.com)

410-470-4238

# QUESTIONS?

Please use the chat feature  
to ask your questions.

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